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Evaluation of a Chrysler Lean Burn Vehicle

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Technology Assessment and Evaluation Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
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16. ABSTRACT

Lean mixture combustion engines are attractive because of the low emissions and good fuel economy that are possible with a properly controlled lean burn engine. Chrysler Corporation has conducted research into engine operation at lean air-fuel ratios and is now planning to market lean burn vehicles.

The U.S. Environmental Protection Agency's Emission Control Technology Division (ECTD) has tested several lean burn vehicles. However, none of these were full [redacted] sized vehicles. Also, none of the previous vehicles used systems that would possibly be marketed soon. ECTD requested a vehicle for testing. Chrysler Corporation made available a lean burn vehicle that ECTD was testing for sulfate emissions.

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Background

Lean mixture combustion engines are attractive because of the low emissions and good fuel economy that are possible with a properly controlled lean burn engine. Chrysler Corporation has conducted research into engine operation at lean air-fuel ratios and is now planning to market lean burn vehicles.

The Emission Control Technology Division (ECTD) has recently tested (Report 75-16, 75-23) several lean burn vehicles. However, none of these were full sized vehicles. Also, none of the previous vehicles used systems that would possibly be marketed soon. ECTD, consistent with its interest in the evaluation of advanced automotive technology, requested a vehicle for testing. Chrysler Corporation made available a lean burn vehicle that ECTD was testing for sulfate emissions.

The Environmental Protection Agency receives information about many systems which appear to offer potential for emissions reduction or improvement in fuel economy compared to conventional engines and vehicles. EPA's Emission Control Technology Division is interested in evaluating all such systems, because of the obvious benefits to the Nation from the identification of systems that can reduce emissions, improve economy, or both. EPA invites developers of such systems to provide to the EPA complete technical data on the system's principle of operation, together with available test data on the system. In those cases in which review by EPA technical staff suggests that the data available show promise for the system, attempts are made to schedule tests at the EPA Emissions Laboratory at Ann Arbor, Michigan. The results of all such tests are set forth in a series of Technology Assessment and Evaluation Reports, of which this report is one.

The conclusions drawn from the EPA evaluation tests are of limited applicability. A complete evaluation of the effectiveness of an emission control system in achieving improvements on the different types of vehicles that are in actual use requires a much larger sample of test vehicles than is economically feasible in the evaluation test projects conducted by EPA. For promising systems it is necessary that more extensive test programs be carried out.

The conclusions from this EPA evaluation test can be considered to be quantitatively valid only for the specific test car used. However, it is reasonable to extrapolate the results from the EPA test to other types of vehicles in a directional or qualitative manner, i.e., to suggest that similar results are likely to be achieved on other types of vehicles.

Vehicle Description

The vehicle tested was Chrysler New Yorker with 440 cubic inch (7210 cc), V-8 engine and a 3-speed automatic transmission. The vehicle was equipped with a prototype Chrysler lean burn system. (The vehicle is described in detail on the following page.)

On this vehicle the lean burn system consisted of an induction system operating at an air to fuel ratio of about 18 to 1. Spark advance was electronically controlled. No exhaust after-treatment was used.

It is understood that the system used on this vehicle is not the same as that planned for production vehicles.

Test Procedures

Exhaust emissions tests were conducted according to the 1975 Federal Test Procedure ('75 FTP), described in the Federal Register of November 15, 1972 except that no evaporative emissions tests were conducted. Additional tests included the EPA Highway Cycle and steady state emissions tests. All tests were conducted using an inertia weight of 5500 pounds (2495 kg) with a road load setting of 15.3 horsepower (11.4 kW) at 50 miles per hour (80.5 km/hr).

Prior to these tests the vehicle was tested for sulfate emissions using the EPA sulfate procedures. These tests were conducted on an electric dynamometer and at a lower road load, 13.9 horsepower (10.4 kW). Therefore the results are not completely comparable. A description of the procedure for measuring sulfate emissions and summary of the test results is given in the appendix.

Test Results

Exhaust emissions data, summarized below, showed that the Chrysler test car, using their lean burn system, achieved the levels of the 1975 Federal emissions standards at low mileage. Detailed results appear in the appendix to this report.

'75 FTP Composite Mass Emissions
grams per mile
(grams per kilometre)

	HC	CO	CO_2	NOx	Fuel Economy (Fuel Consumption)
One Test	.70 (.43)	13.10 (8.14)	963 (598)	2.72 (1.69)	9.0 miles/gal (26.1 liters/100 km)
1975-76 Federal Standards	1.5	15.0		3.1	

On the EPA Highway Cycle the results were:

EPA Highway Cycle Mass Emissions
grams per mile
(grams per kilometre)

	HC	CO	CO_2	NOx	Fuel Economy (Fuel Consumption)
Average of 2 tests	.20 (.12)	2.34 (1.45)	574 (357)	4.74 (2.94)	15.3 miles/gal (15.4 litres/100 km)

Steady state fuel economy results:

Speed mph (km/hr)	Fuel Economy miles/gal	(Fuel Consumption) litres/100 km
15 (24.1)	12.2	(19.3)
30 (48.3)	18.1	(13.0)
45 (72.4)	19.0	(12.4)
60 (96.6)	19.5	(12.1)

A comparison of the test vehicle's combined city/highway fuel economy with that of the 1976 certification Chrysler 440 (as published in the 1976 Buyer's Guide) showed that the test car had a fuel economy penalty of 12%. When compared to all vehicles in the same inertia weight class (5500 lbs) the test car showed a 17% fuel economy penalty.

Vehicle	City/Highway Combined Fuel Economy miles/gal	(Fuel Consumption) litres/100 km
Chrysler Lean Burn (440 CID)	11.0	(21.3)
Chrysler Certification Vehicle (440 CID)	12.5	(18.8)
Average of all 5500 lb Vehicles (ave. 456 CID)	13.3	(17.7)

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1975 Chrysler New Yorker
Emission control system - Chrysler Lean Burn

Engine

type	4 stroke, Otto cycle, V-8
bore x stroke	4.32 x 3.75 in./109.7 x 95.3 mm
displacement	440 cu in./7210 cc
compression ratio	8.2:1
maximum power @ rpm	215 hp/160 kW (est.) @ 4000 rpm
fuel metering	single 4 barrel carburetor
fuel requirement	regular leaded, tested with 100 RON Indolene HO unleaded

Drive Train

transmission type	3 speed automatic
final drive ratio	2.71

Chassis

type	unitized body/frame, front engine, rear wheel drive
tire size	JR 78 x 15
curb weight	5086 pounds
inertia weight	5500 pounds
passenger capacity	6

Emission Control System

basic type	lean combustion (mixture) system
distributor	electronic spark advance
durability accumulated on system	3,100 miles

$$MPG_{combined} = \frac{1}{\frac{.55}{MPG_{urban}} + \frac{.45}{MPG_{highway}}}$$

In calculating city/highway combined fuel economy, the urban fuel economy is weighted 55% and the highway fuel economy is weighted 45% to account for the 55/45 ratio of urban to rural mileage accumulation.

Sulfate emission test results are summarized in the appendix and show sulfate levels of less than 1 mgpm which is similar to non-catalyst vehicles. The car had previously run on leaded fuel which may have caused trace quantities of residue lead to be emitted along with the sulfates. The residue lead causes an interference in the sulfate analysis. Still, it is felt that the sulfate numbers in this report are accurate. The procedure includes both a '75 FTP and a Highway cycle. The vehicle was tested on an electric dynamometer at a lower road load.

The vehicle exhibited stretchiness* when driven on the road for a driveability evaluation.

Conclusions

This Chrysler New Yorker equipped with a prototype lean burn system met the emission levels required by the 1975 Federal standards at low mileage. This system had a significant fuel penalty. Other lean burn vehicles EPA tested had lower emissions and no fuel penalty.

Sulfate levels were found to be similar to non-catalyst vehicles.

* Stretchiness - A lack of anticipated response to throttle movement. This may occur on slight throttle movement from road load or during light to moderate acceleration.

Table A-1
'75 FTP Mass Emissions
grams per mile

Test Number	Bag 1 Cold Transient					Bag 2 Hot Stabilized					Bag 3 Hot Transient				
	HC	CO	CO_2	NOx	Fuel Economy MPG	HC	CO	CO_2	NOx	Fuel Economy MPG	HC	CO	CO_2	NOx	Fuel Economy MPG
15-1159	1.73	46.50	979	3.16	8.4	.35	3.97	991	2.22	8.9	.59	5.37	897	3.35	9.8
15-1171*						.26	3.91	984	2.09	9.0	.47	3.47	858	2.96	10.3

Table A-2
'75 FTP Composite Mass Emission
grams per mile

Test Number	HC	CO	CO_2	NOx	Fuel Economy MPG
15-1159	.70	13.10	963	2.72	9.0

* Procedural error in starting caused the electric choke to open too soon. This caused a false start and stall in Bag 1. Therefore Bag 1 emissions and 75 FTP composite mass emissions are invalid.

Table A-3
EPA Highway Cycle Mass Emissions
grams per mile

Test Number	HC	CO	CO_2	NOx	Fuel Economy MPG
15-1159	.19	2.35	582	4.93	15.1
15-1171	.21	2.33	566	4.55	15.5

Table A-4
Steady State Mass Emissions
grams per mile

Test Number	Speed MPH	HC	CO	CO_2	NOx	Fuel Economy MPG
15-1160*	Idle	.15	.96	179	.17	1.22
15-1161	15	.56	3.84	718	.54	12.2
15-1190	30	.29	2.51	485	.89	18.1
15-1191	45	.40	2.64	461	5.05	19.0
15-1192	60	.17	2.76	451	6.45	19.5

* grams per minute/gallons per hour

Table A-5
Sulfate Procedure Emissions
Average Emissions
grams per mile

Test Type	HC	CO	CO_2	NOx	Fuel Economy MPG	H_2SO_4*	% Conversion
75 FTP	.79	13.58	886	2.58	9.7	.33	.1
Highway	.21	2.47	522	3.86	16.8	1.29	.8
Sulfate Cycle	.17	2.36	626	3.20	14.1	.51	.3
30 MPH	.58	2.10	369	1.91	23.8	.42	.4
60 MPH	.27	2.57	491	6.12	17.9	.63	.4

* milligrams per mile

mileage accumulation done with leaded fuel

Chrysler Lean Burn System

Procedures used to measure sulfate emissions

1. The fuel was drained from the test vehicle. The vehicle was refueled with Indolene HO gasoline containing 0.030% sulfur by weight.

2. The vehicle was prepped by driving on the EPA vehicle preparation route and over one LA-4 cycle.

3. The following sequence of test cycles was used to measure sulfate emissions.

a) cold start 75 FTP
b) three EPA highway driving cycle
c) three hot start sulfate cycles
d) two hours at 30 mph
e) two hours at 60 mph
f) cold start 75 FTP on following day.